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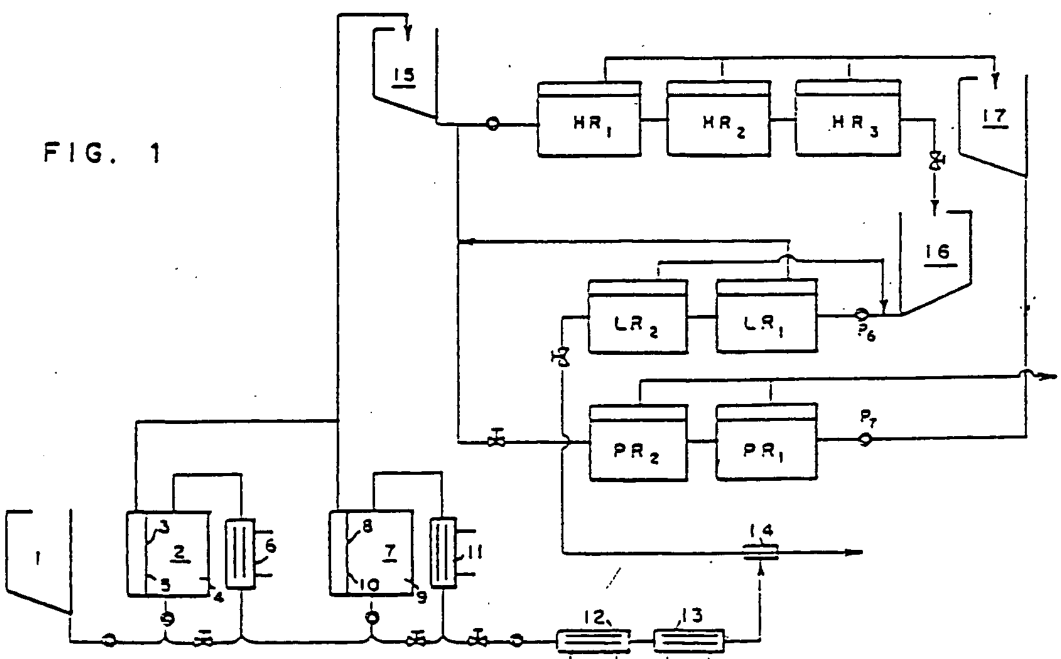
(54) Reverse osmosis concentration of juice products with improved flavor.

(57) A membrane process for producing an improved product quality comprising feeding a clarified serum at an elevated pressure to a plurality of reverse osmosis units in two stages -the first having high-rejection polyamide membranes and the second having low-rejection membranes, wherein the permeate from the low-rejection membranes is recycled to the high-rejection feed.

FIG. 1



EP 0 404 390 A1

The UF permeate is fed to a reverse osmosis (RO) unit to concentrate the flavor and aroma components as a RO retentate. The RO retentate, free of most of the spoilage microorganisms which remained in the UF retentate, can be recombined with the inactivated UF retentate to make a storage stable product, for example, a 50° Brix orange juice product capable of storage at about -4° C for at least 12 months without spoiling.

Nevertheless, it has been found that flavor and aroma losses still occur and the final product quality is not so good as desired. This is now hypothesized as being due to two factors. It is felt that some flavor and aroma components are retained in the UF retentate even though the pore size (about 20,000 to 100,000 MWCO) theoretically should allow all such components (molecular weight of about 30 to 155) to pass through. Additionally, it is felt that the product is adversely affected if the processing time for the UF retentate is too long even if the process time is at low temperatures.

By using UF membranes sized to allow the flavor and aroma components to pass through as suggested in U.S.'902, a gel layer forms on the surface of the membrane reducing the effective pore size and resulting in retention of the smaller aroma and flavor components in the UF retentate. Also, the membranes tend to become plugged, particularly at high concentrations of soluble and insoluble components. As the membrane becomes plugged, the processing time for the UF retentate increases and product quality declines. By using a tighter UF membrane, plugging can be minimized but flavor and aroma components may be retained in the UF retentate instead of passing through into the UF permeate as desired.

Furthermore, some of the flavor and aroma components that are fed to the food juice RO concentrators taught in the art pass through into the RO permeate which is discarded.

Our Patent Application EP-A-(AD-5776), filed on the same date as the present application and incorporated herein by reference, teaches an improved process for separating a clarified serum permeate containing flavor and aroma components from a bottoms stream retentate containing spoilage microorganisms. It employs a plurality of microfiltration/ultrafiltration stages, the first of which being equipped with a membrane having a pore size that retains spoilage microorganisms but that is substantially larger than the flavor and aroma components. Pore sizes of subsequent ultrafilters are decreased in size. The aroma and flavor components as well as the sugar, amino acids and the like in the combined UF permeate may be concentrated using an RO system, and the RO retentate may be recombined with the UF retentate after the UF retentate is treated to inactivate spoilage microorganisms.

The RO system of U.S.'902 has further limitations since final concentration depends on the operating pressure needed to overcome the osmotic pressure of the concentrated juice, the viscosity of the concentrate and fouling caused by pectin and other ingredients. Thus, a juice concentrate of about 25° to 30° Brix is typically produced. By employing membranes operable at higher pressures (1500 pounds per square inch gauge), a clarified orange juice, for example, can be concentrated to about 42° Brix.

U.S. Patent No. 3,617,550 discloses a process for concentrating a feed solution by forcing it through a series of high-rejection membranes, discarding or recycling the permeate and then further concentrating the retentate using a series of low-rejection membranes where the osmotic pressure of the retentate exceeds the working pressure of the low-rejection membranes. Preferably, the permeate from the low-rejection membranes is recycled to the feed to the high-rejection membranes. The process enables production of concentrates having osmotic pressures of several thousand pounds per square inch gauge (psig), which is above the working pressure of the reverse osmosis membranes taught. Orange juice concentrate, for example, with an osmotic pressure of three to four thousand psig would be about 60 to 65° Brix.

Summary of Invention

An improved process has been discovered for concentrating the clarified serum containing flavor and aroma components of a food juice. Preferably the serum is from a permeate from an ultrafilter used to separate clarified serum permeate from bottom solids retentate as taught in U.S. Patent No. 4,643,902 or, more preferably, from the combined permeates from a plurality of microfiltration/ultrafiltration (MF/UF) stages in series wherein a MF/UF retentate from any stage is fed to the subsequent stage and MF/UF permeates from all stages are combined as taught in our co-pending application (AD-5776).

The process of this application comprises concentration of the aroma and flavor components as well as the sugar, amino acids and the like by feeding a clarified serum at elevated pressure to a two-stage reverse osmosis (RO) system, the first stage employing high-rejection polyamide membranes and the second stage employing low-rejection membranes, preferably polyamide membranes.

The high-rejection stage may be comprised of a series of RO units in which the RO retentate from the any RO unit feeds the subsequent RO unit with the RO retentate of the last unit in the series

ter 7.

Ultrafilter 7 is operated in the same manner as microfilter 2, the primary difference being that the pore size of porous membrane 8 is smaller than the pore size of porous membrane 3. Preferably, the pore size of porous membrane 8 has a molecular weight cut-off (MWCO) of 20,000 to 200,000. The pressure is adjusted as necessary to cause a stream containing small molecules to pass through the membrane 8 into the permeate side 10 while retaining larger molecules on the retentate side 9. The permeate is combined with permeates from other MF/UF units for further processing if concentration is desired. The retentate is either recycled to ultrafilter 7 for temperature control or fed to a pasteurizer or other inactivation means to effectively inactivate spoilage microorganisms and other undesired components collected in the concentrated retentate.

Figure 1 shows the inactivation means as pasteurizer 12, which can be operated at about 62° C for about 30 minutes or, preferably, at higher temperatures for shorter periods (85° C for 15 to 20 seconds) to sufficiently inactivate the undesired microorganisms. The microorganisms will be sufficiently inactivated with about a 98% to 99% kill. Temperatures and time needed for a 100% kill, are more likely to abuse the product causing a "burned" flavor.

The inactivated stream from pasteurizer 12 should be cooled immediately after pasteurization in heat exchanger 13, preferably to less than 15° C, more preferably 8° to 10° C. It then may be mixed in mixing device 14 with the concentrated serum from the RO concentrating system of this invention to make a storage stable product, that is for example, ≥ 50° Brix orange juice product capable of storage at about -4° C for at least 12 months without noticeable effect on juice quality, particularly upon reconstituting.

The clarified serum, which is depicted as the combined UF permeate from the microfiltration/ultrafiltration system but may be from any known source, is fed to reverse osmosis (RO) feed tank 15 from which it is pumped with a pressure increasing means P_5 to a first stage of RO permeators, depicted by HR_1, HR_2 and HR_3, equipped with high-rejection membranes. Additional RO units may be employed if desired.

The membranes used in these high-rejection RO units are membranes having a rejection of greater than 95%, preferably greater than 98% [as measured after one hour at 800 psig (5515 kPa), 30% conversion (recovery), with a 30,000 part per million sodium chloride solution at 25° C]. The membranes preferably are polyamides, more preferably aromatic polyamides. They may be the asymmetric type as disclosed in U.S. Patent No. 3,567,632, which is incorporated herein by reference, which are totally aromatic in character. They may contain alicyclic residues such as those derived from cyclohexane-1,3,5-tricarbonyl chloride as employed in U.S. Patents No. 4,520,044 and No. 4,643,829, which are incorporated herein by reference.

The membranes further are such that they can be operated at the trans-membrane pressures (pressure drop across the membrane) of this invention. Preferably, they are of hollow-fiber construction but other geometries or means allowing trans-membrane pressures of this invention may be used (for example, membrane may be formed on a substrate).

The trans-membrane pressure to HR_1 is elevated, that is, above about 1000 psig, preferably 1500 to 2000 psig, more preferably 1500 psig. The feed temperature preferably is less than 15° C, more preferably 8° to 10° C.

The retentate from HR_1 feeds HR_2, the retentate from HR_2 feeds HR_3 and the retentate from HR_3 feeds the low-rejection stage of RO units (LR_1 and LR_2). The Figure depicts an optional feed tank 16 and pump P_5 which can be used to increase the pressure to the low-rejection section if the high-rejection stage is run at lower pressure. Preferably the low-rejection RO units are operated at elevated trans-membrane pressure, that is, above about 1000 psig, preferably 1500 to 2000 psig, more preferably 2000 psig. The feed temperature preferably is less than 15° C, more preferably 8° to 10° C.

The membranes employed in the low-rejection stage may be of any RO membrane material known in the art, but preferably are the same material and geometry as those used in the high-rejection stage. They have a lower rejection, that is higher salt passage as measured by the test described above, than the high-rejection membranes. The preferred limits are discussed below. Preferably, the membranes are hollow fibers but other geometries or means allowing trans-membrane pressures of this invention may be used (for example, membrane may be formed on a substrate).

The permeate from high-rejection RO units HR_1, HR_2 and HR_3 are combined for further processing in a preferred polishing system depicted as polisher feed tank 17, pump P_7, and polisher RO units PR_1 and PR_2. The polishers permit recovery of flavor and aroma components that may pass through the high-rejection membranes. They may be run as depicted, that is, with the retentate of PR_1 feeding PR_2 and the retentate of PR_2 being recycled to the high-rejection RO unit feed with the combined permeates being discharged to waste water. Alternatively, the polishers may be operated in a manner that the permeate of PR_1 feeds PR_2

rejection RO unit and the permeate, primarily water, is discarded.

The RO retentate leaving the final high-rejection RO unit is fed at a trans-membrane pressure of 2000 psig to two low-rejection RO units in series, the first being equipped with a membrane having a 93% salt passage and the second being equipped with a membrane having a 97% salt passage. The retentate of the first having a sugar concentration of 50° Brix is the feed to the second. The permeate from the first having a sugar concentration of 18° Brix and that of the second having a sugar concentration of 40° Brix are combined to form a 31° Brix combined permeate which is recycled to the feed to the first high-rejection unit.

The retentate from the second low-rejection unit having a sugar concentration of 63° Brix is mixed with the retentate from the ultrafilter to make a fully blended 54° Brix product having superior taste, that is comparable to the fresh juice feed.

Claims

1. A membrane process for preparing a concentrated superior-tasting food juice comprising the steps of:

(a) feeding a clarified serum to a multi-stage reverve osmosis (RO) system, wherein the serum is fed at a trans-membrane pressure of 1000 psig or greater to the first stage of the system which comprises one or more RO units having high-rejection polyamide membranes in which the retentate of one unit is fed to the subsequent unit if there are more than one; and

(b) feeding the retentate from the last of the high-rejection RO units at a trans-membrane pressure of 1000 psig or greater to the second stage which comprises one or more RO units having low-rejection membranes, wherein the retentate of each low-rejection RO unit is fed to the subsequent unit if there are more than one and wherein all permeates from the second stage are ultimately recycled to the first stage.

2. The process of claim 1 wherein the permeates from each unit in the second stage are fed to the feed side of the preceding RO unit.

3. The process of claim 1 or 2 wherein the trans-membrane pressure in the first stage is 1500 psig and the trans-membrane pressure in the second stage is 2000 psig.

4. The process of claim 1, 2 or 3 wherein the membrane in stage one is a hollow fiber aromatic polyamide membrane.

5. The process of any one of claims 1 to 4 further comprising feeding the permeate from the first stage to a polisher stage which comprises one or more RO units having high-rejection polyamide membranes wherein the retentate from the polisher stage is recycled to the first stage.

6. The process of any one of claims 1 to 5 wherein there is more than one low-rejection RO unit and the permeate from each is fed to a preceding RO unit having a feed concentration that is essentially the same as that of the recycled permeate.

7. A membrane process for preparing a concentrated storage-stable superior-tasting food juice comprising the following steps:

(a) providing from a juice-bearing fruit or vegetable a juice suitable for ultrafiltration;

(b) permeating said juice first through an ultrafiltration stage which stage is equipped with a porous membrane having a pore size larger than the size of desirable flavor and aroma components but smaller than undesirable microorganisms to form a permeate stream containing flavor and aroma components and a retentate stream containing undesirable microorganisms;

(c) treating retentate from (b) above to inactivate a sufficient number of undesirable microorganisms to inhibit spoilage of juice under storage conditions; and

(d) feeding permeate from (b) to a multi stage reverve osmosis (RO) system, wherein the serum is fed at a trans-membrane pressure of 1000 psig or greater to the first stage of the system which comprises RO units having high-rejection polyamide membranes in which the retentate of one unit is fed to the subsequent unit and the retentate from the last of the high-rejection RO units is fed at a trans-membrane pressure of 1000 psig or greater to the second stage which comprises RO units having low-rejection membranes, wherein the retentate of each low-rejection RO unit is fed to the subsequent unit and wherein all permeates from the second stage are ultimately recycled to the first stage; to produce a concentrated RO retentate which is combined with the treated retentate of step (c) to produce a storage-stable superior-tasting concentrated product.

8. The process of claim 7 wherein the membrane in stage one of the RO system is a hollow fiber aromatic polyamide membrane.

9. The process of claim 7 or 8 further comprising feeding the permeate from the first stage of the RO system to a polisher stage which comprises one or more RO units having high-rejection polyamide membranes wherein the retentate from the polisher stage is recycled to the first stage.

10. The process of claim 7, 8 or 9 wherein there is more than one low-rejection RO unit in the RO system and the permeate from each is fed to a preceding RO unit having a feed concentration that is essentially the same as that of the recycled permeate.

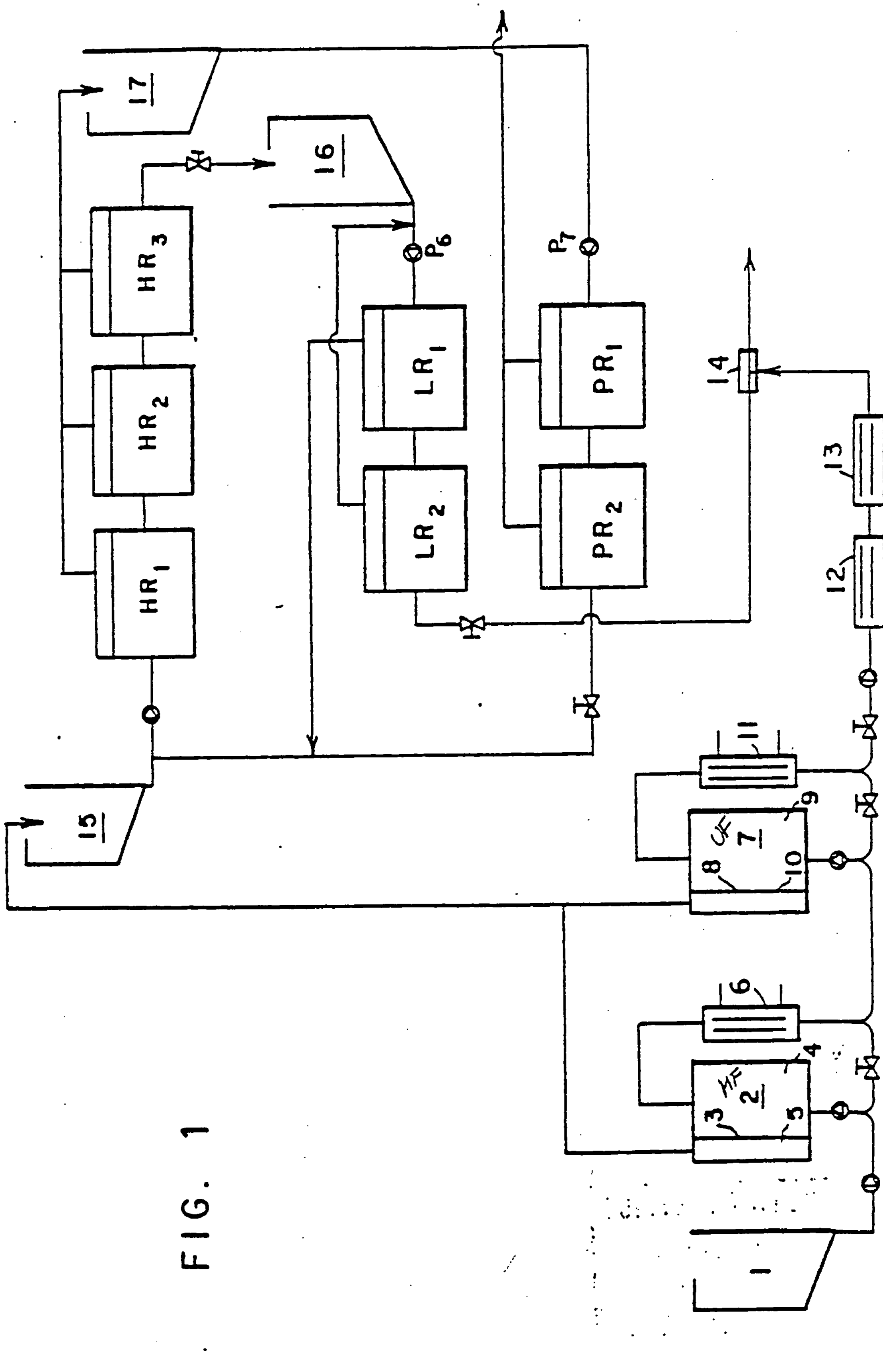

HR1
HR2
HR3
LR1
LR2
PR1
PR2
P6
P7
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
HF
UF

FIG. 1

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EUROPEAN SEARCH REPORT

Application Number

EP 90 30 6168

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	PATENT ABSTRACTS OF JAPAN vol. 3, no. 147 (C-66) 05 December 1979, & JP-A-54 124875 (MITSUI TOATSU) 28 September 1979, * the whole document *	1	A23L2/30 A23L2/08 B01D61/02
D,A	US-A-3617550 (C.E. SAVION) * the whole document *	1	
A	FR-A-2017387 (DU PONT DE NEMOURS) * the whole document *	1	
A	EP-A-170233 (DU PONT DE NEMOURS) * the whole document *	1	
A	EP-A-174594 (THE TEXAS A&M UNIVERSITY SYSTEM) * the whole document *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

A23L
B01D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18 OCTOBER 1990	VAN MOER A.M.J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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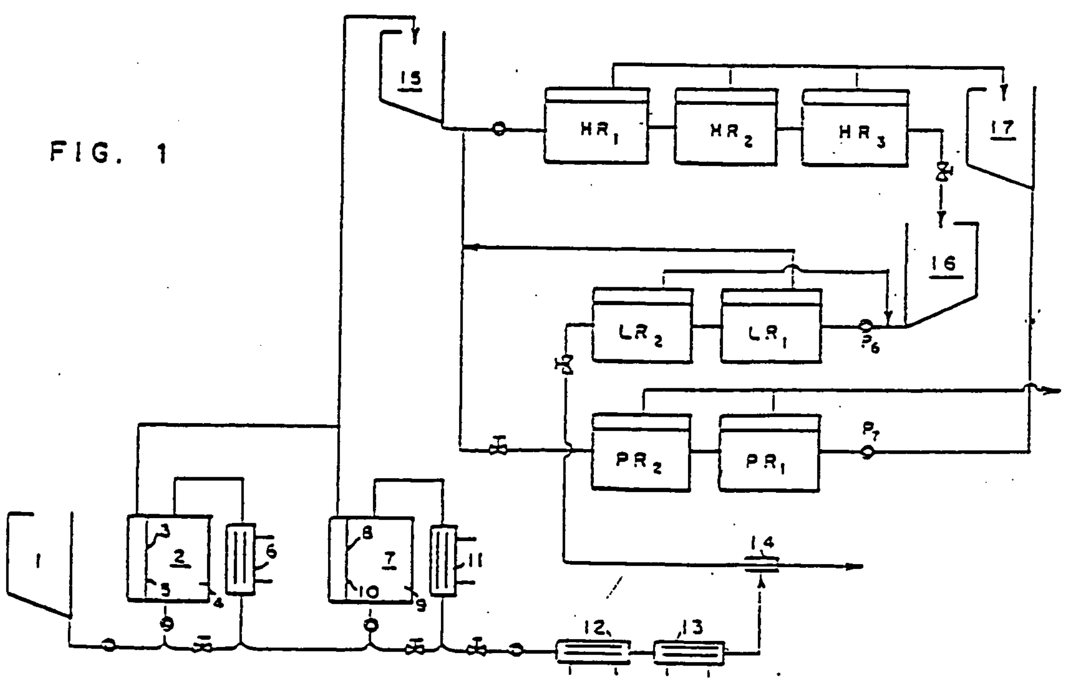
(54) Reverse osmosis concentration of juice products with improved flavor.

(57) A membrane process for producing an improved product quality comprising feeding a clarified serum at an elevated pressure to a plurality of reverse osmosis units in two stages - the first having high-rejection polyamide membranes and the second having low-rejection membranes, wherein the permeate from the low-rejection membranes is recycled to the high-rejection feed.

FIG. 1



The UF permeate is fed to a reverse osmosis (RO) unit to concentrate the flavor and aroma components as a RO retentate. The RO retentate, free of most of the spoilage microorganisms which remained in the UF retentate, can be recombined with the inactivated UF retentate to make a storage stable product, for example, a 50° Brix orange juice product capable of storage at about -4° C for at least 12 months without spoiling.

Nevertheless, it has been found that flavor and aroma losses still occur and the final product quality is not so good as desired. This is now hypothesized as being due to two factors. It is felt that some flavor and aroma components are retained in the UF retentate even though the pore size (about 20,000 to 100,000 MWCO) theoretically should allow all such components (molecular weight of about 30 to 155) to pass through. Additionally, it is felt that the product is adversely affected if the processing time for the UF retentate is too long even if the process time is at low temperatures.

By using UF membranes sized to allow the flavor and aroma components to pass through as suggested in U.S.'902, a gel layer forms on the surface of the membrane reducing the effective pore size and resulting in retention of the smaller aroma and flavor components in the UF retentate. Also, the membranes tend to become plugged, particularly at high concentrations of soluble and insoluble components. As the membrane becomes plugged, the processing time for the UF retentate increases and product quality declines. By using a tighter UF membrane, plugging can be minimized but flavor and aroma components may be retained in the UF retentate instead of passing through into the UF permeate as desired.

Furthermore, some of the flavor and aroma components that are fed to the food juice RO concentrators taught in the art pass through into the RO permeate which is discarded.

Our Patent Application EP-A-(AD-5776), filed on the same date as the present application and incorporated herein by reference, teaches an improved process for separating a clarified serum permeate containing flavor and aroma components from a bottoms stream retentate containing spoilage microorganisms. It employs a plurality of microfiltration/ultrafiltration stages, the first of which being equipped with a membrane having a pore size that retains spoilage microorganisms but that is substantially larger than the flavor and aroma components. Pore sizes of subsequent ultrafilters are decreased in size. The aroma and flavor components as well as the sugar, amino acids and the like in the combined UF permeate may be concentrated using an RO system, and the RO retentate may be recombined with the UF retentate after the UF retentate is treated to inactivate spoilage microorganisms.

The RO system of U.S.'902 has further limitations since final concentration depends on the operating pressure needed to overcome the osmotic pressure of the concentrated juice, the viscosity of the concentrate and fouling caused by pectin and other ingredients. Thus, a juice concentrate of about 25° to 30° Brix is typically produced. By employing membranes operable at higher pressures (1500 pounds per square inch gauge), a clarified orange juice, for example, can be concentrated to about 42° Brix.

U.S. Patent No. 3,617,550 discloses a process for concentrating a feed solution by forcing it through a series of high-rejection membranes, discarding or recycling the permeate and then further concentrating the retentate using a series of low-rejection membranes where the osmotic pressure of the retentate exceeds the working pressure of the low-rejection membranes. Preferably, the permeate from the low-rejection membranes is recycled to the feed to the high-rejection membranes. The process enables production of concentrates having osmotic pressures of several thousand pounds per square inch gauge (psig), which is above the working pressure of the reverse osmosis membranes taught. Orange juice concentrate, for example, with an osmotic pressure of three to four thousand psig would be about 60 to 65° Brix.

Summary of Invention

An improved process has been discovered for concentrating the clarified serum containing flavor and aroma components of a food juice. Preferably the serum is from a permeate from an ultrafilter used to separate clarified serum permeate from bottom solids retentate as taught in U.S. Patent No. 4,643,902 or, more preferably, from the combined permeates from a plurality of microfiltration/ultrafiltration (MF/UF) stages in series wherein a MF/UF retentate from any stage is fed to the subsequent stage and MF/UF permeates from all stages are combined as taught in our co-pending application (AD-5776).

The process of this application comprises concentration of the aroma and flavor components as well as the sugar, amino acids and the like by feeding a clarified serum at elevated pressure to a two-stage reverse osmosis (RO) system, the first stage employing high-rejection polyamide membranes and the second stage employing low-rejection membranes, preferably polyamide membranes.

The high-rejection stage may be comprised of a series of RO units in which the RO retentate from the any RO unit feeds the subsequent RO unit with the RO retentate of the last unit in the series

ter 7.

Ultrafilter 7 is operated in the same manner as microfilter 2, the primary difference being that the pore size of porous membrane 8 is smaller than the pore size of porous membrane 3. Preferably, the pore size of porous membrane 8 has a molecular weight cut-off (MWCO) of 20,000 to 200,000. The pressure is adjusted as necessary to cause a stream containing small molecules to pass through the membrane 8 into the permeate side 10 while retaining larger molecules on the retentate side 9. The permeate is combined with permeates from other MF/UF units for further processing if concentration is desired. The retentate is either recycled to ultrafilter 7 for temperature control or fed to a pasteurizer or other inactivation means to effectively inactivate spoilage microorganisms and other undesired components collected in the concentrated retentate.

Figure 1 shows the inactivation means as pasteurizer 12, which can be operated at about 62 °C for about 30 minutes or, preferably, at higher temperatures for shorter periods (85 °C for 15 to 20 seconds) to sufficiently inactivate the undesired microorganisms. The microorganisms will be sufficiently inactivated with about a 98% to 99% kill. Temperatures and time needed for a 100% kill, are more likely to abuse the product causing a "burned" flavor.

The inactivated stream from pasteurizer 12 should be cooled immediately after pasteurization in heat exchanger 13, preferably to less than 15 °C, more preferably 8° to 10 °C. It then may be mixed in mixing device 14 with the concentrated serum from the RO concentrating system of this invention to make a storage stable product, that is for example, ≥ 50° Brix orange juice product capable of storage at about -4 °C for at least 12 months without noticeable effect on juice quality, particularly upon reconstituting.

The clarified serum, which is depicted as the combined UF permeate from the microfiltration/ultrafiltration system but may be from any known source, is fed to reverse osmosis (RO) feed tank 15 from which it is pumped with a pressure increasing means P_5 to a first stage of RO permeators, depicted by HR_1, HR_2 and HR_3, equipped with high-rejection membranes. Additional RO units may be employed if desired.

The membranes used in these high-rejection RO units are membranes having a rejection of greater than 95%, preferably greater than 98% [as measured after one hour at 800 psig (5515 kPa), 30% conversion (recovery), with a 30,000 part per million sodium chloride solution at 25 °C]. The membranes preferably are polyamides, more preferably aromatic polyamides. They may be the asymmetric type as disclosed in U.S. Patent No. 3,567,632, which is incorporated herein by reference, which are totally aromatic in character. They may contain alicyclic residues such as those derived from cyclohexane-1,3,5-tricarbonyl chloride as employed in U.S. Patents No. 4,520,044 and No. 4,643,829, which are incorporated herein by reference.

The membranes further are such that they can be operated at the trans-membrane pressures (pressure drop across the membrane) of this invention. Preferably, they are of hollow-fiber construction but other geometries or means allowing trans-membrane pressures of this invention may be used (for example, membrane may be formed on a substrate).

The trans-membrane pressure to HR_1 is elevated, that is, above about 1000 psig, preferably 1500 to 2000 psig, more preferably 1500 psig. The feed temperature preferably is less than 15 °C, more preferably 8° to 10 °C.

The retentate from HR_1 feeds HR_2, the retentate from HR_2 feeds HR_3 and the retentate from HR_3 feeds the low-rejection stage of RO units (LR_1 and LR_2). The Figure depicts an optional feed tank 16 and pump P_5 which can be used to increase the pressure to the low-rejection section if the high-rejection stage is run at lower pressure. Preferably the low-rejection RO units are operated at elevated trans-membrane pressure, that is, above about 1000 psig, preferably 1500 to 2000 psig, more preferably 2000 psig. The feed temperature preferably is less than 15 °C, more preferably 8° to 10 °C.

The membranes employed in the low-rejection stage may be of any RO membrane material known in the art, but preferably are the same material and geometry as those used in the high-rejection stage. They have a lower rejection, that is higher salt passage as measured by the test described above, than the high-rejection membranes. The preferred limits are discussed below. Preferably, the membranes are hollow fibers but other geometries or means allowing trans-membrane pressures of this invention may be used (for example, membrane may be formed on a substrate).

The permeate from high-rejection RO units HR_1, HR_2 and HR_3 are combined for further processing in a preferred polishing system depicted as polisher feed tank 17, pump P_7, and polisher RO units PR_1 and PR_2. The polishers permit recovery of flavor and aroma components that may pass through the high-rejection membranes. They may be run as depicted, that is, with the retentate of PR_1 feeding PR_2 and the retentate of PR_2 being recycled to the high-rejection RO unit feed with the combined permeates being discharged to waste water. Alternatively, the polishers may be operated in a manner that the permeate of PR_1 feeds PR_2

rejection RO unit and the permeate, primarily water, is discarded.

The RO retentate leaving the final high-rejection RO unit is fed at a trans-membrane pressure of 2000 psig to two low-rejection RO units in series, the first being equipped with a membrane having a 93% salt passage and the second being equipped with a membrane having a 97% salt passage. The retentate of the first having a sugar concentration of 50° Brix is the feed to the second. The permeate from the first having a sugar concentration of 18° Brix and that of the second having a sugar concentration of 40° Brix are combined to form a 31° Brix combined permeate which is recycled to the feed to the first high-rejection unit.

The retentate from the second low-rejection unit having a sugar concentration of 63° Brix is mixed with the retentate from the ultrafilter to make a fully blended 54° Brix product having superior taste, that is comparable to the fresh juice feed.

Claims

1. A membrane process for preparing a concentrated superior-tasting food juice comprising the steps of:

(a) feeding a clarified serum to a multi-stage reverve osmosis (RO) system, wherein the serum is fed at a trans-membrane pressure of 1000 psig or greater to the first stage of the system which comprises one or more RO units having high-rejection polyamide membranes in which the retentate of one unit is fed to the subsequent unit if there are more than one: and

(b) feeding the retentate from the last of the high-rejection RO units at a trans-membrane pressure of 1000 psig or greater to the second stage which comprises one or more RO units having low-rejection membranes, wherein the retentate of each low-rejection RO unit is fed to the subsequent unit if there are more than one and wherein all permeates from the second stage are ultimately recycled to the first stage.

2. The process of claim 1 wherein the permeates from each unit in the second stage are fed to the feed side of the preceding RO unit.

3. The process of claim 1 or 2 wherein the trans-membrane pressure in the first stage is 1500 psig and the trans-membrane pressure in the second stage is 2000 psig.

4. The process of claim 1, 2 or 3 wherein the membrane in stage one is a hollow fiber aromatic polyamide membrane.

5. The process of any one of claims 1 to 4 further comprising feeding the permeate from the first stage to a polisher stage which comprises one or more RO units having high-rejection polyamide membranes wherein the retentate from the polisher stage is recycled to the first stage.

6. The process of any one of claims 1 to 5 wherein there is more than one low-rejection RO unit and the permeate from each is fed to a preceding RO unit having a feed concentration that is essentially the same as that of the recycled permeate.

7. A membrane process for preparing a concentrated storage-stable superior-tasting food juice comprising the following steps:

(a) providing from a juice-bearing fruit or vegetable a juice suitable for ultrafiltration;

(b) permeating said juice first through an ultrafiltration stage which stage is equipped with a porous membrane having a pore size larger than the size of desirable flavor and aroma components but smaller than undesirable microorganisms to form a permeate stream containing flavor and aroma components and a retentate stream containing undesirable microorganisms:

(c) treating retentate from (b) above to inactivate a sufficient number of undesirable microorganisms to inhibit spoilage of juice under storage conditions; and

(d) feeding permeate from (b) to a multi stage reverve osmosis (RO) system, wherein the serum is fed at a trans-membrane pressure of 1000 psig or greater to the first stage of the system which comprises RO units having high-rejection polyamide membranes in which the retentate of one unit is fed to the subsequent unit and the retentate from the last of the high-rejection RO units is fed at a trans-membrane pressure of 1000 psig or greater to the second stage which comprises RO units having low-rejection membranes, wherein the retentate of each low-rejection RO unit is fed to the subsequent unit and wherein all permeates from the second stage are ultimately recycled to the first stage: to produce a concentrated RO retentate which is combined with the treated retentate of step (c) to produce a storage-stable superior-tasting concentrated product.

8. The process of claim 7 wherein the membrane in stage one of the RO system is a hollow fiber aromatic polyamide membrane.

9. The process of claim 7 or 8 further comprising feeding the permeate from the first stage of the RO system to a polisher stage which comprises one or more RO units having high-rejection polyamide membranes wherein the retentate from the polisher stage is recycled to the first stage.

10. The process of claim 7, 8 or 9 wherein there is more than one low-rejection RO unit in the RO system and the permeate from each is fed to a preceding RO unit having a feed concentration that is essentially th same as that of the recycled permeate.

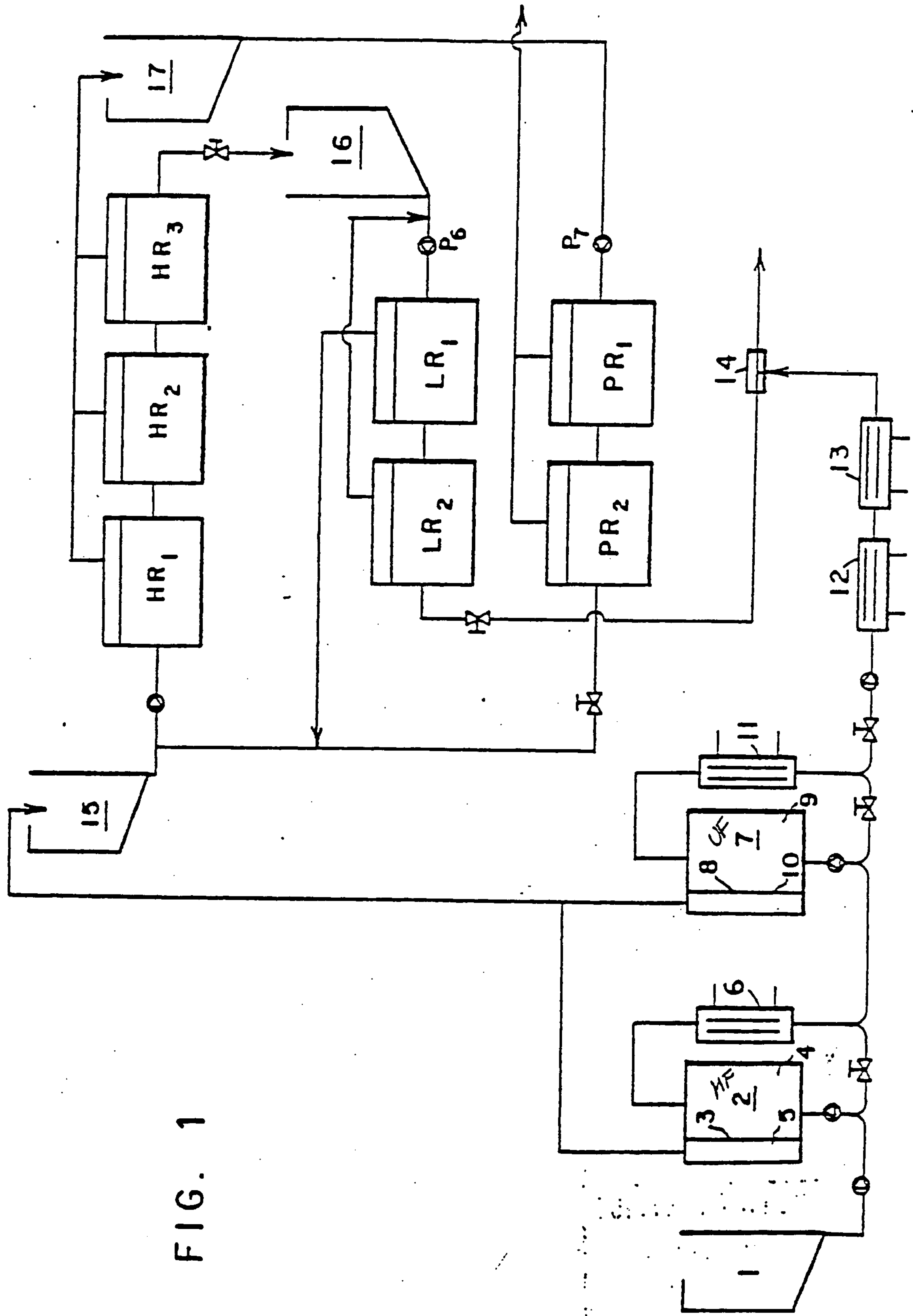

HR1
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FIG. 1

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 30 6168

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	PATENT ABSTRACTS OF JAPAN vol. 3, no. 147 (C-66) 05 December 1979, & JP-A-54 124875 (MITSUI TOATSU) 28 September 1979, * the whole document *	1	A23L2/30 A23L2/08 B01D61/02
D,A	US-A-3617550 (C.E. SAVION) * the whole document *	1	
A	FR-A-2017387 (DU PONT DE NEMOURS) * the whole document *	1	
A	EP-A-170233 (DU PONT DE NEMOURS) * the whole document *	1	
A	EP-A-174594 (THE TEXAS A&M UNIVERSITY SYSTEM) * the whole document *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

A23L
B01D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18 OCTOBER 1990	VAN MOER A.M.J.

CATEGORY OF CITED DOCUMENTS

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